

Claim Amendments
Including a complete listing of all claims

1. (Currently Amended) A method of stabilizing the polarization of a vertical cavity surface emitting laser (VCSEL) device, comprising:

forming a plurality of symmetrical VCSEL elements capable of emitting substantially a single mode radiation of substantially the same wavelength and arranged to have a laterally patterned reflectivity so as to allow phase coupling between at least two of the plurality of symmetrical VCSEL elements, and

initiating emission of radiation by injecting current within a range assuring a single mode of operation into the at least two of the plurality of VCSEL elements to produce phase-coupled radiation, wherein the polarization direction of each of the at least two of the plurality of symmetrical VCSEL elements remains substantially constant during operation and exhibit an equal probability for radiating in one of two linear polarization states.

2. (Original) The method of claim 1 further comprising:

providing a phase-coupling region having a lateral dimension and a longitudinal dimension, substantially perpendicular to the major emission direction of the VCSEL device, the lateral dimension being less than the longitudinal dimension, wherein the lateral dimension is in the range from about 7 μm to about 0.1 μm .

3. (Original) The method of claim 1, wherein in each VCSEL element, a radiation window is provided with a size from about 40 μm^2 to about 1 μm^2

4. (Original) The method of claim 1, wherein a reflectivity difference between a resonator region corresponding to a radiation window of each of the VCSEL elements and a phase-coupling region provided between adjacent VCSEL elements is selected to be within about 0.5% to 15%.

5. (Original) The method of claim 1, wherein two to five VCSEL elements are provided.

6. (Previously Presented) The method of claim 1, wherein the at least two of the plurality of VCSEL elements are top-emitting VCSEL elements.

7. (Original) The method of claim 4, further comprising:
providing a phase-coupling region, at least partially, as an
electrically conductive material.

8. (Original) The method of claim 7, wherein the phase-
coupling region is provided on top of a distributed Bragg
reflector to define radiation windows corresponding to each VCSEL
element.

9. (Original) The method of claim 7, wherein the phase-
coupling region is used as an injection electrode for injecting
current.

10. (Original) The method of claim 7, wherein the phase-
coupling region is provided as a grid layer vertically arranged
between a first mirror means and a second mirror means.

11. (Original) The method of claim 7, further comprising:
providing a second phase-coupling region dividing each of
the VCSEL elements into two or more sub portions, the second
phase-coupling region generating a second reflectivity difference
between resonator regions covered by the second phase-coupling
region and resonator regions not covered by the second phase-
coupling region, wherein the second reflectivity difference

differs from the reflectivity difference created by the phase-coupling region.

12. (Previously Presented) The method of claim 1, wherein the at least two of the plurality of VCSEL elements are arranged as an array defined by a phase-coupling region formed on top of a top Bragg reflector of the VCSEL device.

13. (Original) The method of claim 12, wherein the phase-coupling region is provided as a grid layer, that is at least partially conductive, and is used to inhomogeneously inject current.

14. (Original) The method of claim 13, wherein stripes of said grid layer extending along a first direction and stripes extending along a second direction are supplied with different currents respectively.

15. (Original) The method of claim 14, wherein a radiation emitting surface of each of the VCSEL elements is substantially of square shape, rectangular shape, diamond shape, or hexagonal shape

16. (Original) The method of claim 12, wherein the array is asymmetric.

17. (Original) The method of any of claims 1 to 16, further comprising:

providing a polarization adjusting means to select a pre-defined polarization direction.

18. (Original) The method of claim 17, further comprising:
providing a strain element in the polarization adjusting means to produce orientation-dependent strain in one or more of the VCSEL elements.

19. (Original) The method of claim 18, further comprising:
providing a means for selecting a pre-defined orientation of said orientation-dependent strain.

20. (Original) The method of claim, 1 wherein the VCSEL elements are operated in a continuous wave mode.

21. (Currently Amended) A polarization-stable VCSEL device comprising:

two to five phase-coupled VCSEL elements having a common resonator placed in an array, with each of said phase-coupled VCSEL elements being configured to provide a substantially

identical probability for lasing in two different linear polarization states when operated in a single mode; and

a phase-coupling region comprising a reflectivity difference adjusted by a phase-matching layer placed between the phase-coupled VCSEL elements,

wherein, during operation within a drive current range assuring a single mode of operation, the polarization direction of each of the phase-coupled VCSEL elements remains substantially constant due to the phase-coupling of the phase-coupled VCSEL elements.

22. (Currently Amended) A polarization-stable VCSEL device comprising:

a plurality of phase-coupled VCSEL elements placed in an array;

a phase-coupling region comprising a reflectivity difference adjusted by a phase-matching layer placed between each of said plurality of phase-coupled VCSEL elements, wherein during operation with a drive current within a range assuring a single mode of operation the polarization direction of each of the VCSEL elements remains substantially constant in a pre-defined polarization direction due to the phase-coupling of the VCSEL elements and exhibiting a substantially equal probability for radiating in one of two linear polarization states; and

a polarization adjusting means provided in one or more of the phase-coupled VCSEL elements to select the pre-defined polarization direction.

23. (Original) The polarization-stable VCSEL device of claim 22, wherein the polarization adjusting means comprises a strain element to produce an orientation-dependent strain in one or more of the phase-coupled VCSEL elements.

24. (Original) The polarization-stable VCSEL device of claim 23, wherein said strain element comprises a strain layer including one or more shrunk material layers to create said orientation-dependent strain.

25. (Original) The polarization-stable VCSEL device of claim 22, wherein the polarization adjusting means comprises electrodes adapted to allow inhomogeneous injection of current into the VCSEL elements.

26. (Original) The polarization-stable VCSEL device of claim 25, wherein said electrodes are arranged in accordance with a crystallographic orientation of a substrate on which the VCSEL device is formed.

27. (Original) The polarization-stable VCSEL device of claim 25, wherein electrodes oriented in a first crystallographic direction are electrically insulated from electrodes oriented in a second crystallographic direction.

28. (Original) The polarization-stable VCSEL device of claim 22, wherein the plurality of phase-coupled VCSEL elements are arranged in an array defined by a grid layer comprising electrically conductive portions.

29. (Original) The polarization-stable VCSEL device of claim 28, wherein first stripes of the grid layer extend along a first direction and second stripes extend along a second direction whereby a width of the first stripes is less than a width of the second stripes.

30. (Original) The polarization-stable VCSEL device of claim 28 or 29, wherein said array is asymmetric.

31. (Original) The polarization-stable VCSEL device of claim 28, wherein each element of the array is of square shape.

32. (Original) The polarization-stable VCSEL device of claim 28, wherein each element of the array is of rectangular shape.

33. (Original) The polarization-stable VCSEL device of claim 22, wherein respective emission windows of said plurality of VCSEL elements are of polygonal shape.

34. (Currently Amended) The polarization-stable VCSEL device of claim 21, ~~further comprising~~ wherein:

~~a~~ the phase-matching layer is on top of a distributed Bragg reflector, the phase-matching layer adjusting a reflectivity difference of the VCSEL resonator area below a radiation window and below a region separating two adjacent VCSEL elements to about 0.5 to about 3%.

35. (Once Amended) The polarization-stable VCSEL device of claim 21 further comprising a grid layer.

36. (Original) The polarization-stable VCSEL device of claim 35, wherein said grid layer generates a reflectivity difference of about 0.50% to 15%.

37. (Original) The polarization-stable VCSEL device of claim 28, wherein a width of stripes of the grid layer is in the range of about 7 μm to about 0.1 μm .

38. (Original) The polarization-stable VCSEL device of claim 35, wherein a width of stripes of the grid layer is in the range of about 7 μm to about 0.1 μm .

39. (Currently Amended) A vertical cavity surface emitting laser array device comprising:

a first reflector;

a second reflector;

a cavity placed between said first and second reflector;

a plurality of vertical cavity surface emitting laser elements formed on said first reflector; and

a phase coupling region having a laterally patterned reflectivity so as to couple phases of ~~separating each of~~ said plurality of vertical cavity surface emitting laser elements,

whereby the polarization direction of at least two of said plurality of vertical cavity surface emitting laser elements remain substantially constant during operation.

40. (Previously Presented) A vertical cavity surface emitting laser array device as in claim 39 wherein:

said phase coupling region comprises a metal grid.

41. (Previously Presented) A vertical cavity surface emitting laser array device as in claim 39 wherein:

said phase coupling region comprises a reflectivity difference between a resonator region of one of said plurality of vertical cavity surface emitting laser elements and said phase coupling region.

42. (Previously Presented) A vertical cavity surface emitting laser array device as in claim 41 wherein:

the reflectivity difference is selected to be within 0.50 and 15 percent.

43. (Previously Presented) A vertical cavity surface emitting laser array device as in claim 39 further comprising:

means, associated with at least two of said plurality of vertical cavity surface emitting laser elements, for providing a desired polarization direction.

44. (Previously Presented) A method of stabilizing the polarization of a vertical cavity surface emitting laser array device comprising:

forming a plurality of vertical cavity surface emitting laser elements; and

phase coupling at least two of the plurality of vertical cavity surface emitting laser elements,

whereby the polarization direction of the at least two of said plurality of vertical cavity surface emitting laser elements remain substantially constant during operation.

45. (New) A vertical cavity surface emitting laser array device comprising:

a first reflector;

a second reflector;

a cavity placed between said first and second reflector;

a plurality of vertical cavity surface emitting laser elements formed on said first reflector, said plurality of vertical cavity surface emitting laser elements having a first reflectivity; and

a grid formed adjacent said plurality of vertical cavity surface emitting laser elements, said grid having a predetermined width and a second reflectivity;

said first reflectivity and said second reflectivity having a reflectivity difference between 1 and 15 percent,

whereby a phase coupling region is formed between said plurality of vertical cavity surface emitting laser elements

resulting in the polarization direction of radiation from said plurality of vertical cavity surface emitting laser elements remaining substantially constant during operation.

46. (New) A vertical cavity surface emitting laser array device as in claim 45 further comprising:

a phase matching layer having a predetermined thickness formed adjacent said second reflector,

wherein the predetermined width of said grid and the predetermined thickness of said phase matching layer are adjusted so as to cause phase coupling between said plurality of vertical cavity surface emitting laser elements.

47. (New) A method of operating a polarization sensitive application using vertical cavity surface emitting laser elements whereby the polarization of the vertical cavity surface emitting laser elements is established, the method comprising:

providing two or more vertical cavity surface emitting laser elements having a common optical resonator and emitting substantially a single mode radiation of substantially the same wavelength when drive current is injected into the two or more vertical cavity surface emitting laser elements, the two or more vertical cavity surface emitting laser elements each being configured to have a substantially identical probability for

establishing two different linear polarization states when operated in the single mode regime, said common resonator having a laterally patterned reflectivity so as to couple the phases of the two or more vertical cavity surface emitting laser elements; and

supplying an output radiation of the two or more vertical cavity surface emitting laser elements to said polarization sensitive application, wherein said output radiation is substantially devoid of polarization flips between said two linear polarization states within a drive current range assuring a single mode operation.

48. (New) A polarization-stable vertical cavity surface emitting laser device, wherein the vertical cavity surface emitting laser device is configured to provide its total output radiation by

an arrangement of two to five phase-coupled vertical cavity surface emitting laser elements wherein during operation the polarization direction of each of the vertical cavity surface emitting laser elements remains substantially constant, each vertical cavity surface emitting laser element being configured to provide a substantially identical probability for lasing in two different linear polarization states when operated in the single mode regime, said two to five vertical cavity surface

emitting laser elements having a common resonator, wherein a lateral reflectivity of the resonator is patterned by a phase matching layer and a grid layer.